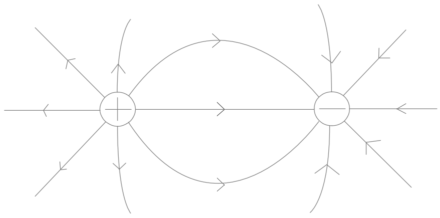
1.

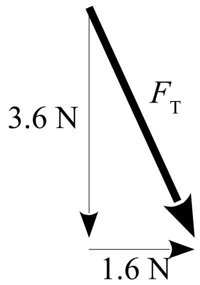
(a)



(b) Let $r_1 = 0.10$ m, $r_2 = 0.30$ m

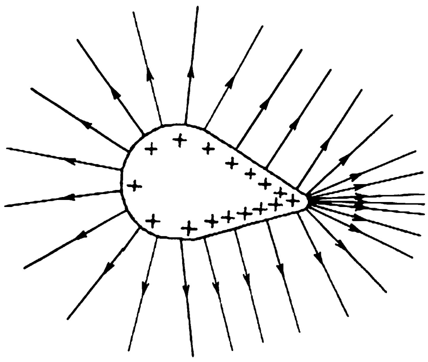
$$F_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_1^2} = 9.00\times10^9 \times \frac{2.0\times10^{-6}\times2.0\times10^{-6}}{0.10^2} = 3.6 \text{ N towards bottom of page}$$

$$F_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_3}{r_2^2} = 9.00\times10^9 \times \frac{2.0\times10^{-6}\times8.0\times10^{-6}}{0.30^2} = 1.6 \text{ N to the right}$$



$$F_T = \sqrt{1.6^2 + 3.6^2} = 3.9 \text{ N}$$

2. (don't need to show the charges, just the field)



3.

$$E=\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

q is constant, $\frac{1}{4\pi\varepsilon_0}$ is constant

$$\therefore \mathrm{E}\propto\frac{1}{r^2}$$

$$\therefore \frac{E_1}{E_2}=\frac{1/r_1^2}{1/r_2^2}=\frac{r_2^{\ 2}}{r_1^{\ 2}}$$

$r_1=r$

$r_2=3r$

$$\therefore \frac{E_1}{E_2}=\frac{(3r)^2}{r^2}=\frac{9r^2}{r^2}=\frac{9}{1}$$

So the ratio $E_1:E_2$ is 9:1

4.

(a) $\Delta E_K=W=q\Delta V=1.60\times10^{-19}\times895=1.43\times10^{-16}$ J

(b) 894 eV

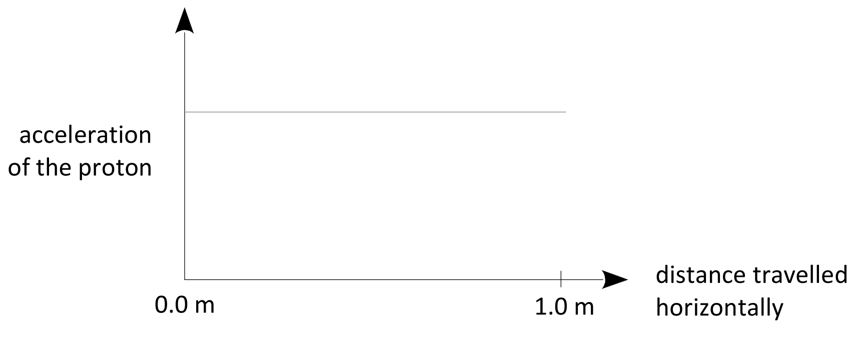
(c) $E=\frac{\Delta V}{d}=\frac{895}{0.15}=5.97\times10^3\ \mathrm{NC^{-1}}$

5.

(a) $t=\frac{d}{v}=\frac{1.0}{4.9\times10^4}=2.0\times10^{-5}$ s

(b) $a=\frac{F}{m}=\frac{Eq}{m}=\frac{1.2\times1.6\times10^{-19}}{1.67\times10^{-27}}=1.15\times10^8\ \mathrm{ms^{-2}}$

(c)



(d) $s=v_0t+\tfrac{1}{2}at^2=0\times2.0\times10^{-5}+\tfrac{1}{2}\times1.15\times10^8\times\left(2.0\times10^{-5}\right)^2$

$=0.023$ m

6.

(a) to the left

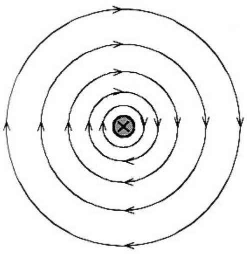
(b) $F=BI\Delta l\sin\theta$

$=2.4\times10^{-4}\times0.125\times58\times\sin90°$

$=1.7\times10^{-3}$ N

7.

(a)

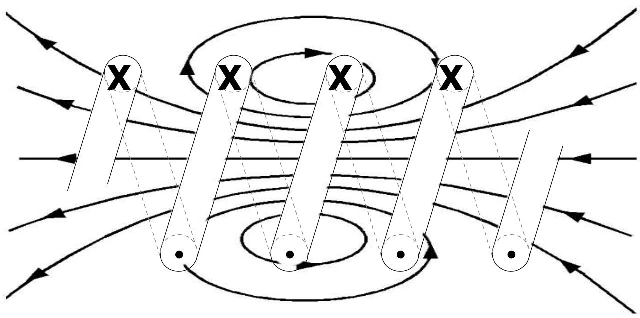


(b) $B = \frac{\mu_0}{2\pi}\frac{I}{r}$

$= 2.00\times10^{-7} \times \frac{25}{3.2\times10^{-2}}$

$= 1.6\times10^{-4}\ \text{T}$

(c)



8.

(a) The direction of the magnetic field (would be out of page) -OR- The position of the target (e.g. to the left). In the present set-up an electron would move in clockwise motion which would not match the target.

(b) $a = \frac{v^2}{r}$ $\{\text{centripetal acceleration}\}$

$\therefore F = \frac{mv^2}{r}$ $\{a \text{ inserted into } F = ma\}$

$F = qvB\sin\theta$

$= qvB$ $\{\text{since } \theta = 90° \text{ so } \sin\theta = 1\}$

$\therefore qvB = \frac{mv^2}{r}$ $\{\text{equating the two equations for } F\}$

$\therefore qB = \frac{mv}{r}$

$\therefore rqB = mv$

$\therefore r = \frac{mv}{qB}$

(c) $10.0\times10^{6}\times1.60\times10^{-19} = 1.60\times10^{-12}$ J

$K = \frac{q^2B^2r^2}{2m}$

$\therefore B = \sqrt{\frac{2mK}{q^2r^2}} = \sqrt{\frac{2\times1.67\times10^{-27}\times1.60\times10^{-12}}{\left(1.60\times10^{-19}\right)^2\left(1.00\right)^2}} = 0.457\ \text{T}$

Note: Be careful marking this; if you forget the eV to J conversion but also lose a squared you will end up with the correct answer by accident.

(d) After 50 revolutions, $K = 10.0$ MeV

The proton crosses ΔV twice per revolution

$\therefore$ Work done by ΔV is $\dfrac{10.0\times10^6}{50\times2} = 1.0\times10^5$ eV

Proton has same charge as an electron, so $\Delta V = 1.0\times10^5$ V

(or you could convert eV to J and then use $W = q\Delta V$)

(e) Radioisotopes are used in medicine (as a radioactive tracer)

9.

The purpose of the dees of a cyclotron is to increase the speed of the ion. The dees are oppositely charged hollow conductors, which means there is an electric field set up between them but no electric field inside of them, so the electric field does work on the charge it each time it crosses the gap between the dees and no other time.

The period of motion of an ion in a cyclotron is not affected by the speed of the particle, as supported by the formula $T = \dfrac{2\pi m}{qB}$ (v does not appear in the formula). This means that the alternating current supplying the opposite charges to the dees can remain at a constant frequency, and the particle will always cross the gap between the dees at the right time to gain speed.

10.

(a) $\Phi = BA_{\perp}$

$= 0.13\times(0.38\times0.50) = 0.025$ Wb

(b) new $\Phi = BA_{\perp}$

$= 0.13\times(0.38\times0.30) = 0.015$ Wb

$$\therefore emf = \frac{\Delta\Phi}{\Delta t}$$
$$= \frac{0.025-0.015}{4.5}$$
$$= 0.0022 \text{ V}$$

11.

(a) A generator contains a fixed magnet and a rotating coil of wire. As the coil moves through the magnetic field, it experiences a change in flux through the loops. This change in flux over time induces an emf in the coil and therefore electric current.

(b) $\dfrac{V_S}{V_P} = \dfrac{n_S}{n_P}$

$$\therefore V_S = V_P \times \frac{n_S}{n_P}$$
$$= 20\times10^3 \times \frac{360}{22} = 327 \text{ kV}$$
$$I = \frac{P}{V} = \frac{582\times10^6}{327} = 1.8 \text{ kA}$$

(c) Step-up.